I may add that it is often a convenience to know at what rate the refraction in declination varies during an exposure. This may be computed in a similar manner. From the second of equations (α) we find

$$\Delta\delta = \Delta\zeta \cos \eta = \beta \tan \zeta \cos \eta,$$

or

$$\Delta\delta = \beta \cdot \frac{\cos \delta \sin \phi - \sin \delta \cos \phi \cos h}{\sin \delta \sin \phi + \cos \delta \cos \phi \cos h}.$$

And since the apparent declination (δ') is equal to $\delta + \Delta\delta$, we have

$$\frac{d\delta'}{d\theta'} = \frac{d\Delta\delta}{d\theta} = \beta \cdot \frac{\sin \phi \cos \phi \sin h}{\{\sin \delta \sin \phi + \cos \delta \cos \phi \cos h\}^2} \quad . \quad . \quad . \quad . \quad (\gamma)$$

Hence we see that the apparent declination is always increasing on the west and always diminishing on the east of the meridian, as is otherwise obvious.

With the same substitution as before, we can write this expression in the form

$$\frac{d\delta'}{d\theta'} = \beta \frac{\cos \phi \, . \cos \nu}{\sin^2 n \sin^2 (m + \delta)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (\delta)$$

which is very convenient for computation.

This also varies within limits, which, in comparison with the accuracy of which measurements of stellar photographs are susceptible, may be considered wide. It is of course zero on the meridian, while at a zenith distance of 60° (at which it is possible to get first-rate photographs for measurement) it may amount to as much as $0''\cdot5$ per minute.

Dunsink Observatory:
1896 *December* 1.

Observations of the Leonids on 1896 *November* 13 *and* 14.

By Prof. Arthur A. Rambaut, M.A., D.Sc.

Although our observations this year at Dublin of the meteors belonging to the *Leonid* stream fall far short of what we hoped for, and in point of accuracy and completeness leave a good deal still to be desired, yet in view of the unfavourable character of the weather, which prevented observations at so many other stations, the results we obtained may possibly be of value, and ought at least to be put on record.

Cloudy weather prevented observations on the night of November 12.

On the 13th my assistant, Mr. Charles Martin, commenced his watch at $12^h\ 55^m$ G.M.T. At that time it was very cloudy in the east, with a film of thin clouds all over the sky, which began to clear up shortly afterwards, and by $13^h\ 55^m$ had quite disappeared. The first meteor was recorded at $14^h\ 16^m$, and was followed by others as exhibited in the following table :—

Table I.

Observation of Meteors, 1896 *November* 13.

No.	Time first seen G.M.T. d h m	Point first seen at.	Mag.	Colour.	Notes.
1	13 14 16	π Leonis	2	Yellow	
2	14 25	o ,,	1	White	
3	14 45	Orion	1	Red	
4	14 47	λ Leonis	4	White	
5	14 49	κ ,,	4	,,	
6	15 0	ζ ,,	3	,,	
7	15 1	o ,,	4	,,	
8	15 1	Orion—Leo	1	,,	
9	15 2	ζ Leonis	1	Red	Seen for 14^s. Drifted N.E.
10	15 13	Between γ and ζ Leonis	4	White	
11	15 16	,, ν and o Leonis	4	Yellow	
12	15 20	o Leonis	0	White	
13	15 31	ρ ,,	3	,,	
14	15 40	ϵ Ursæ Majoris	−1	Yellow	Came from ϵ Ursæ Maj. and lasted till it reached Regulus.
15	15 44	θ Leonis	2	White	
16	15 47	κ ,,	3	,,	
17	15 51	Between α Leonis and Jupiter	2	,,	
18	15 56	20 Leonis	3	,,	
19	16 0	θ ,,	4	Red	
20	16 3	λ ,,	2	Bright red	
21	16 25	γ ,,	−2	White	
22	16 40	η ,,	1	Yellow	

$12^h\ 55^m$, cloudy in E, clearing up, though very thin clouds all over the sky.
$13^h\ 55^m$, quite clear.
$16^h\ 55^m$, clouded up.
Moon set about $13^h\ 40^m$. Age at noon Nov. 13, $8^d\ 5^h$.

The last meteor was noticed at $16^h\ 40^m$ when the clouds

began to gather once more, and by $16^h\ 55^m$ the sky was so hopelessly overcast that the watch was discontinued.

The tracks of these meteors were plotted down by Mr. Martin at the time upon a map of the constellation *Leo* prepared before hand, and the results of his observations are reproduced in fig. 1.

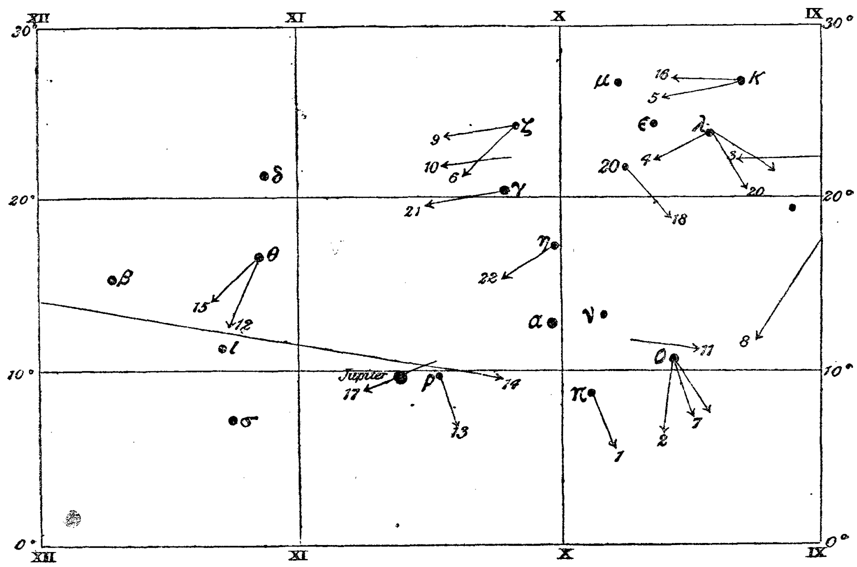

FIG. 1.—Meteor Tracks, 1896 November 13.

On the following day I attached a camera to the tube of our photographic equatorial in the hope of getting automatic records of some of the brighter meteor-trails. The lens was a rapid-rectilinear of $1\frac{1}{4}$ inch diameter (of which the full aperture was used), and about $8\frac{1}{2}$ inches equivalent focus. But although I employed Cadett & Neale's Lightning plates, $7\frac{1}{2}$ by 5 inches in size, which thus covered a region of about $50° \times 33°$ upon the sky, and although several of the meteors crossed the field of view covered by the lens, not a single one of them was bright enough to leave a trace upon the photograph.

It will at once be objected that the lens was too small, and, of course, I did not venture to hope that I should succeed in getting photographs of all the meteors which we saw; but I was disappointed to find that even the brighter ones, which appeared of about the first or second stellar magnitude, left no trace upon the plate.

My experiment, therefore, although the result is of a negative character, may possibly be of some use in affording a lower limit to the aperture of lens which can be used for this purpose with any prospect of success, and if the fainter meteors are looked for the lens will have to be of much larger dimensions.

Unfortunately this photographic experiment was not only unsuccessful, but was positively detrimental to the completeness of our watch on this night; for on account of the temporary and make-shift character of the apparatus I found it necessary to

call Mr. Martin in to help me in removing and replacing the cap.

His own observations, which he conducted as on the previous night, were in this way three times interrupted, but a continuous watch was maintained by him

	h	m		h	m	
from	13	40	to	13	50	G.M.T.
,,	14	19	,,	15	19	,,
,,	15	32	,,	16	31	,,
,,	16	53	,,	17	49	,,

and his results are given in the following table :—

Table II.

Observation of Meteors, 1896 *November* 14.

No.	Time first seen (G.M.T.) d h m	Point first seen at.	Mag.	Colour.	Notes.
1	14 13 46	Between ζ and μ Leonis	1	White	Seen for 4^s.
2	14 26	Between Jupiter and θ Leonis	2	,,	
3	14 28	β Leonis	2	,,	
4	14 32	Between μ and ϵ Leonis	1	Yellow	Seen for 5^s.
5	14 42	o Leonis	4	White	
6	15 3	,,	4	,,	
7	15 3	θ ,,	4	,,	
8	15 19	η ,,	6	Red	
9	15 40	δ ,,	4	White	
10	15 41	o ,,	3	Red	
11	15 41	θ ,,	2	White	Seen for 4^s.
12	15 47	β ,,	4	,,	
13	15 52	Between Jupiter and γ Leonis	2	,,	
14	16 0	δ Leonis	5	Yellow	
15	16 3	o ,,	4	,,	
16	16 6	γ ,,	2	,,	
17	16 7	ϵ ,,	3	White	
18	16 10	Between Jupiter and θ Leonis	4	Yellow	
19	16 11	ζ Leonis	1–2	White	$1\frac{1}{2}^\circ$ long.
20	16 11	β ,,	2	,,	
21	16 15	α Cancri (?)	4	,,	
22	16 25	Jupiter	1	,,	
23	17 1	ρ Leonis	2	,,	
24	17 23	ν ,,	4	,,	
25	17 47	20 ,,	4	,,	

Moon set about 14^h 49^m, age at noon November 14 9^d 5^h.

F

The tracks as plotted down by him are represented in fig. 2.

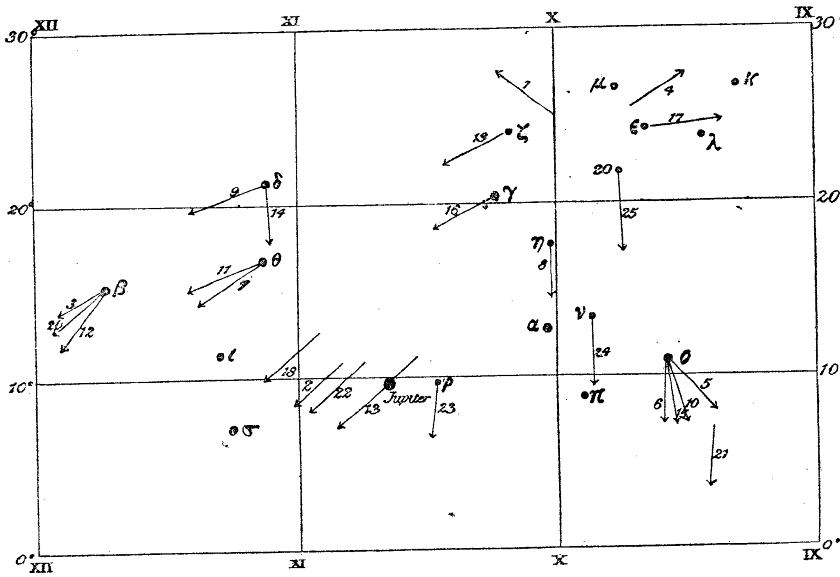

Fig. 2.—Meteor Tracks, 1896 November 14.

From the observations as given above we deduce the following table, giving the number of meteors seen in each successive period of ten minutes on the two mornings :—

Table III.

G.M.T.	No. of meteors seen on Nov. 13.	No. of meteors seen on Nov. 14.	G.M.T.	No. of meteors seen on Nov. 13.	No. of meteors seen on Nov. 14.
h m			h m		
13 40			50		
	0	1		2	1
50			16 0		
	0	[0]		2	3
14 0			10		
	0	[0]		0	4
10			20		
	1	[0]		1	1
20			30		
	1	1		0	[0]
30			40		
	0	1		1	[0]
40			50		
	2	1		...	0
50			17 0		
	0	0		...	1
15 0			10		
	3	2		...	0
10			20		
	2	1		...	1
20			30		
	1	[0]		...	0
30			40		
	1	0		...	1
40			50		
	2	4			

At first sight these observations seem to point to an increase in the number of meteors on both mornings in the interval between $14^h\ 30^m$ and $16^h\ 30^m$, which, if real, would be difficult to account for. I think, however, the apparent falling off in point of numbers towards the end of the first night's watch is possibly due to a gradual coming on of clouds, which is very likely to have preceded total obscuration, although Mr. Martin has not recorded it; and on the second night the light of the Moon, which set about $14^h\ 49^m$, and the small altitude of the constellation *Leo* at first may have conspired to render some of the meteors invisible. The increase in numbers at $14^h\ 40^m$ on November 13 and the falling off after $16^h\ 30^m$ on November 14 seem to be real, as the sky was clear at both times; and, I think, a more probable deduction from these observations, if, indeed, they are not too meagre to afford a basis for any such deduction, is that the densest part of the swarm which we passed through this year was encountered during the interval between our two watches—perhaps during the daylight hours of Saturday, 14th.

From the tracks as laid down by Mr. Martin, it would appear that the meteor trails of November 14 diverge much more nearly from a point than do those of the 13th; and although I would not rely too much on the absolute accuracy of any track—for I think the number of trails which are drawn as issuing from stars would show that the proximity of a bright star has biassed the observer's estimate of the position of the meteor's path—yet I am inclined to think that the greater divergence of the trails recorded on November 14 is not a mere chance result of errors of observation, but points to a real difference in the character of the paths on the two occasions.

In this connection I may remark, although, indeed, the fact might be used as an argument against this conclusion, that the three meteors which Mr. Martin notes as having lasted for several seconds, thus affording him a better opportunity of determining their paths, seemed to diverge almost exactly from the radiant point, as determined by Mr. Denning and given in the *Admiralty Manual* for 1886.